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Review Article

Hemostasis in periodontal surgery: Current strategies and advances

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Abstract

Hemostasis is a critical component in periodontal surgical procedures. Efficient control of bleeding is not only essential for optimal visualization and surgical precision but also vital for minimizing postoperative complications and promoting effective wound healing. This review discusses the fundamental principles of intraoperative and postoperative hemostasis, explores traditional methods and hemostatic agents, and provides an updated perspective on cutting-edge techniques, such as autologous platelet concentrates, chitosan-based agents, nanotechnology-integrated materials, and tranexamic acid applications. Emphasis is placed on both local and systemic factors influencing bleeding and the importance of individualized surgical planning.

Keywords: Hemostatic, Gingivectomy, Fibrinolysis

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1. Introduction

Hemostasis is a vital component of successful periodontal surgical procedures, ensuring not only a clear operative field but also optimal healing and postoperative outcomes. Defined as the physiological process of arresting bleeding, hemostasis is critical in both intraoperative and postoperative phases of surgery. In the context of periodontal surgery—where soft tissue manipulation, bone exposure, and vascular injury are common—achieving effective hemostasis is essential for surgical precision, reduced operative time, and patient comfort.[1]

Periodontal surgeries, including flap operations, gingivectomies, osseous recontouring, and implant-related procedures, often involve areas of rich vascular supply. Inadequate hemostatic control can lead to complications such as excessive bleeding, hematoma formation, delayed healing, and increased risk of infection. Moreover, hemostasis is closely tied to visualization of the surgical field, which directly influences the accuracy of debridement, root planing, and regeneration procedures.[2]

Traditionally, mechanical pressure, suturing, and vasoconstrictive agents have been employed to achieve hemostasis. However, recent advancements in biomaterials and pharmaceutical science have introduced novel topical agents, bioactive dressings, and regenerative adjuncts with superior hemostatic and wound-healing properties. The use of platelet-rich fibrin (PRF), chitosan-based materials, and self-assembling peptides, for instance, has opened new avenues in enhancing both hemostasis and tissue regeneration in periodontal therapy.[3]

Additionally, with an increasing number of patients on anticoagulant and antiplatelet therapy, periodontists are often

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faced with the challenge of managing bleeding risks while maintaining systemic safety. This makes understanding the principles of hemostasis, the range of available hemostatic agents, and their appropriate clinical applications more crucial than ever.

This review aims to provide a comprehensive overview of the mechanisms, methods, materials, and modern advances in hemostasis as they apply to periodontal surgery. Emphasis is placed on evidence-based strategies that improve clinical outcomes while minimizing risks associated with bleeding in the surgical periodontal setting.

2. Physiology of Hemostasis[4-6]

Hemostasis is a complex and tightly regulated physiological process that prevents excessive blood loss following vascular injury. It involves the interaction of blood vessels, platelets, coagulation factors, and fibrinolytic systems. Understanding the phases of hemostasis is essential for periodontal surgeons to anticipate and manage bleeding effectively during and after surgical procedures.

Hemostasis occurs in three coordinated phases:

2.1. Primary hemostasis

Primary hemostasis begins immediately following vascular injury and involves:

1. **Vasoconstriction:** Local injury to the blood vessel causes a transient reflex vasoconstriction mediated by endothelin and neural reflexes. This reduces blood flow to the affected area temporarily.
2. **Platelet Adhesion:** Exposed subendothelial collagen and von Willebrand factor (vWF) attract circulating platelets, which adhere to the damaged endothelium.
3. **Platelet Activation:** Adherent platelets undergo activation, changing shape and releasing granules (e.g., ADP, thromboxane A2, serotonin), which recruit more platelets to the site.
4. **Platelet Aggregation:** Additional platelets aggregate to form a temporary platelet plug, effectively sealing small vascular injuries.

2.2. Secondary hemostasis

While the platelet plug forms a temporary seal, secondary hemostasis strengthens it by forming a stable fibrin clot. This involves activation of the **coagulation cascade**, which proceeds through:

1. **Intrinsic pathway** (triggered by trauma inside the vascular system)
2. **Extrinsic pathway** (triggered by external trauma causing blood to escape from the vascular system)
3. **Common pathway** (convergence of both pathways)

These cascades involve a series of clotting factors (I to XIII) that sequentially activate one another, culminating in the transformation of **fibrinogen (Factor I)** into **fibrin**, forming a stable mesh that reinforces the platelet plug.

In the oral cavity, tissue trauma during periodontal surgery activates both intrinsic and extrinsic pathways due to the rich vascular network and exposure to oral tissues.

2.3. Tertiary hemostasis (Fibrinolysis)

After the vessel injury is repaired, the clot is no longer needed. The body initiates **fibrinolysis**, which dissolves the fibrin mesh through the action of **plasmin**, ensuring that clot formation does not obstruct blood flow unnecessarily. Balance between coagulation and fibrinolysis is crucial for maintaining vascular integrity without promoting thrombosis.

2.4. Regulation of Hemostasis[7]

Hemostasis is finely balanced by natural anticoagulants (such as protein C, protein S, and antithrombin III) and fibrinolytic inhibitors. Any disruption in this balance can lead to either excessive bleeding (e.g., in patients with hemophilia or on anticoagulants) or pathological clotting (e.g., thrombosis).

In the periodontal setting, surgical trauma, systemic health status, and medications can influence all phases of hemostasis. Therefore, understanding the underlying physiology aids clinicians in selecting appropriate hemostatic measures tailored to the patient's needs and the surgical complexity.

2. Classification of Hemostatic Methods in Periodontal Surgery

Hemostasis in periodontal surgery can be achieved through various techniques and materials, each selected based on the extent of bleeding, surgical procedure involved, and the patient’s systemic condition. These methods can be broadly classified into mechanical, thermal, chemical, and biological approaches.

Table 1: Classification of hemostatic methods in periodontal surgery[8-11]

Category	Method	Examples / Agents	Mechanism of Action	Clinical Application
Mechanical	Direct Pressure	Sterile gauze, cotton roll	Physical compression of vessels	Minor bleeding, flap surgeries
	Suturing	Resorbable or non-resorbable sutures	Wound closure reduces bleeding surface	All surgical procedures
	Surgical Dressing	Coe-Pak	Protective layer, mild pressure	Postoperative protection and minor bleeding

	Bone Wax	Sterile bone wax	Seals bleeding bone surfaces mechanically	Osseous recontouring, implant sites
Thermal	Electrocautery	Electric cautery units	Heat coagulation of blood vessels	Moderate to heavy bleeding; flap and gingival surgeries
	Laser Coagulation	Diode, CO_2, Nd:YAG lasers	Thermal coagulation and sealing of vessels	Soft tissue surgeries, flap procedures
Chemical / Topical	Vasoconstrictors	Lignocaine with adrenaline (1:80,000 or 1:100,000)	Vasoconstriction reduces capillary bleeding	Routine infiltrations, surgical extractions
	Astringents	Aluminum chloride (20–25%), ferric sulfate (15–20%)	Protein precipitation, vasoconstriction	Sulcular bleeding control, retraction cord placement
	Antifibrinolytics	Tranexamic acid (mouth rinse, soaked gauze)	Inhibits fibrinolysis	Patients on anticoagulants, post-operative bleeding control
	Oxidizers	Hydrogen peroxide (3%)	Mechanical cleansing, mild clot promotion	Minor soft tissue bleeding
	Monsel's Solution	Ferric subsulfate	Aggressive coagulation	Localized capillary bleeding
Biological	Gelatin-based Agents	Gelfoam	Absorbs blood, scaffold for clotting	Moderate bleeding, socket management
	Oxidized Regenerated Cellulose	Surgicel	Forms artificial clot, promotes clotting	Bone and soft tissue surgical sites
	Microfibrillar Collagen	Avitene	Activates platelets, enhances aggregation	Soft tissue surgeries, grafting sites
	Fibrin Sealants	Tisseel, Evicel	Mimics fibrin formation step in coagulation	Persistent bleeding, regenerative surgeries
	Autologous Platelet Concentrates	PRP, PRF	Enhances clot formation, growth factor delivery	Flap, graft, implant and regenerative procedures

3. Hemostatic Considerations in Specific Periodontal Procedures[12-14]

Periodontal surgery encompasses a wide range of procedures, each varying in technique, tissue involvement, and bleeding potential. Effective hemostatic management must be tailored to the specific surgical approach, the vascularity of the site, and the individual patient's systemic status. Below are key hemostatic considerations for commonly performed periodontal procedures:

4.1. Flap surgery (Modified widman, full/partial thickness flaps)

Bleeding Profile: Moderate bleeding due to reflection of mucoperiosteal flaps and exposure of vascular connective tissue.

4.2. Hemostatic considerations

1. Use of vasoconstrictor-containing local anesthetics for initial control.
2. Gentle flap handling and precise incision placement to minimize trauma.
3. Suturing for tension-free closure aids in reducing post-op bleeding.
4. Application of collagen sponges or PRF in high-risk cases.

4.2. Gingivectomy and Gingivoplasty

Bleeding Profile: High bleeding potential due to soft tissue excision without flap elevation; especially in inflamed gingiva.

4.3. Hemostatic considerations

1. Pre-surgical scaling and anti-inflammatory therapy to reduce vascularity.
2. Laser gingivectomy (e.g., diode, Nd:YAG) offers better hemostasis compared to scalpel technique.
3. Use of chemical hemostats like aluminum chloride or ferric sulfate may be required.
4. Electrocautery can also be employed for effective bleeding control.

4.3. Osseous surgery

Bleeding Profile: Moderate to severe; exposure and reshaping of alveolar bone can result in significant bleeding from marrow spaces.

4.4. Hemostatic considerations

1. Bone wax may be applied to control bleeding from bony surfaces.
2. Oxidized cellulose or gelatin-based dressings can be used post-debridement.
3. Thorough irrigation to remove blood clots that may obscure visibility during contouring.

4.4. Mucogingival and root coverage procedures

Bleeding Profile: Moderate; involves manipulation of attached gingiva, periosteum, and sometimes donor tissue.

4.5. Hemostatic considerations

1. Achieve primary closure with minimal tension using appropriate suturing techniques.
2. PRF membranes can aid in hemostasis and enhance healing.
3. Gentle tissue handling minimizes trauma and bleeding.

4.5. Periodontal regenerative procedures

Bleeding Profile: Variable depending on defect morphology and surgical technique.

4.6. Hemostatic considerations

1. Controlled bleeding is desirable to stimulate clot formation and support regenerative materials (e.g., GTR membranes, bone grafts).
2. Excessive bleeding can wash away graft material—thus, hemostasis must be precise.
3. Use of PRF and platelet concentrates improves both clot stability and tissue regeneration.

4.6. Dental implant placement and peri-implant surgeries

Bleeding Profile: Depends on the vascularity of the ridge and proximity to vital structures.

4.7. Hemostatic considerations

1. Evaluate for anatomical landmarks (e.g., mental foramen) pre-operatively to avoid arterial injury.
2. Application of absorbable hemostats (e.g., collagen plugs) into extraction sockets or osteotomies when needed.
3. Suturing with minimal flap tension enhances post-op hemostasis.

4.7. Crown lengthening procedures

Bleeding Profile: Mild to moderate; involves removal of soft tissue and sometimes alveolar bone.

4.8. Hemostatic considerations

Use of laser or electrocautery improves visualization and minimizes bleeding.

Aluminum chloride or ferric sulfate may help control bleeding during impression-taking in restorative phase.

5. Advances in Hemostasis[17-19]

With evolving surgical techniques and an increasing number of medically complex patients undergoing periodontal procedures, the need for rapid, efficient, and tissue-friendly hemostatic solutions has driven significant innovation in recent years. Traditional mechanical and chemical methods, while effective, may not always suffice in complex or high-risk cases. Recent advances in biomaterials, nanotechnology, and biotechnology have introduced novel agents and strategies that offer superior bleeding control, improved healing, and even regenerative potential.

Table 2: Hemostatic key considerations by procedure type[15-16]

Procedure	Bleeding Potential	Key Hemostatic Strategies
Flap Surgery	Moderate	Vasoconstrictors, sutures, collagen sponge, PRF
Gingivectomy / Gingivoplasty	High	Laser/electrocautery, chemical hemostats ($AlCl_3$, $FeSO_4$)
Osseous Surgery	Moderate to High	Bone wax, Surgicel, Gelfoam, saline irrigation
Mucogingival Surgery	Moderate	Primary closure, PRF, careful tissue handling
Regenerative Procedures	Variable	Controlled bleeding, PRF, fibrin sealants, careful graft handling
Implant Placement	Mild to Moderate	Pre-op radiographic planning, collagen plugs, flap suturing
Crown Lengthening	Mild to Moderate	Lasers, chemical astringents, careful soft/bone tissue excision

5.1. Platelet concentrates: PRF and PRP

1. Platelet-Rich Plasma (PRP) and Platelet-Rich Fibrin (PRF) are autologous blood derivatives rich in platelets, fibrin, and growth factors.
2. Apart from enhancing hemostasis through rapid clot formation, they promote angiogenesis, soft tissue healing, and bone regeneration.
3. PRF is easier to prepare, cost-effective, and does not require anticoagulants, making it highly suitable for periodontal procedures.

5.2. Application

Flap surgeries, graft stabilization, peri-implant defects, root coverage procedures.

5.2. Chitosan-based hemostatic agents

1. Derived from crustacean shells, chitosan is a natural polysaccharide with biocompatible, biodegradable, and antimicrobial properties.
2. Chitosan-based dressings (e.g., Hem Con®, Celox Dental®) initiate clotting by attracting red blood cells and platelets through ionic interactions.
3. They provide immediate bleeding control and also serve as a wound barrier.

5.3. Application

Extraction sockets, surgical wounds in patients with bleeding disorders.

5.3. Self-assembling peptide hydrogels

1. Novel synthetic peptides (e.g., **PuraStat®**) form a clear hydrogel upon contact with blood, creating a physical barrier that promotes rapid hemostasis.
2. These hydrogels are highly biocompatible and do not interfere with tissue healing.
3. Their transparent nature allows continued surgical visibility.

Application: Precision control in microsurgeries, mucogingival procedures, peri-implant defects.

5.4. Bioactive glasses and mineral-based hemostats

Bioactive glass (e.g., PerioGlas®) promotes clotting and bone regeneration by releasing calcium and phosphate ions. *Kaolin-based dressings* activate the intrinsic clotting pathway by stimulating Factor XII.

Application: *Bone grafting, sinus lifts, peri-implant regenerative procedures.*

5.5. Advanced collagen-based products

1. Newer formulations of *microfibrillar collagen and absorbable collagen sponges* have improved porosity and hemostatic capacity.
2. Collagen promotes platelet aggregation and serves as a scaffold for tissue repair.

5.6. Application

Periodontal regeneration, grafting, post-extraction bleeding.

5.6. Hemostatic nanofibers and nanomaterials

1. Nanotechnology-enabled dressings provide large surface area and enhanced clotting efficiency.
2. Electrospun nanofibers embedded with antimicrobial or pro-coagulant agents offer dual benefit: bleeding control and infection prevention.
3. Still in experimental stages but show promising future applications in periodontal microsurgery.

5.7. Fibrin sealants with enhanced bioactivity

1. Recombinant or pooled plasma-derived fibrin sealants (e.g., Tisseel®, Evicel®) now incorporate antifibrinolytic agents (e.g., aprotinin) for more stable clots.
2. Newer formulations also integrate growth factors or antibiotics to enhance therapeutic potential.

5.8. Application

GTR, sinus augmentation, and procedures involving soft tissue regeneration.

Table 3: Key advantages of advanced hemostatic agents.20-21

Feature	Benefit
Faster clot formation	Reduced surgical and post-operative bleeding
Biocompatibi lity	Reduced risk of tissue necrosis or inflammation
Regenerative potential	Enhanced healing of soft and hard tissues
Ease of application	Improved surgical efficiency and patient comfort
Use in high-risk patients	Safer options for anticoagulated or systemically compromised cases

These innovations in hemostatic technology are not only transforming the way periodontists manage intraoperative bleeding but are also enhancing wound healing, reducing complications, and improving patient outcomes. As newer materials become more accessible and cost-effective, their routine integration into periodontal surgical practice is anticipated.

4. Discussion

Hemostasis plays a pivotal role in the success of periodontal surgical procedures, not only by minimizing intraoperative blood loss but also by contributing significantly to optimal healing and postoperative outcomes. A clear surgical field enhances the precision of periodontal debridement, root planing, and regenerative procedures, ultimately influencing long-term treatment success. Inadequate control of bleeding can obscure the operative site, prolong surgery, increase the risk of infection, and delay healing.[22]

This review has highlighted the wide spectrum of hemostatic strategies available, ranging from conventional mechanical methods to modern bioengineered materials. Mechanical techniques, such as gauze pressure, suturing, and the use of surgical dressings, remain fundamental in daily practice. However, the growing complexity of periodontal surgeries and the increasing prevalence of patients on antiplatelet or anticoagulant therapy have necessitated the adoption of advanced adjuncts such as topical hemostatics, biologics, and regenerative materials.[23]

The use of local vasoconstrictors, such as adrenaline-containing anesthetics, remains an effective first-line strategy for controlling capillary bleeding. However, their use must be cautious in medically compromised patients, especially those with cardiovascular conditions. Chemical agents like ferric sulfate and aluminum chloride, although efficient for superficial bleeding, can cause tissue irritation and discoloration if overused. Thus, precise application and case selection are crucial.

One of the major advancements in hemostasis has been the incorporation of biological agents such as platelet-rich fibrin (PRF) and platelet-rich plasma (PRP), which not only aid in clot formation but also promote angiogenesis and soft tissue healing. Their dual function in achieving hemostasis and enhancing tissue regeneration makes them ideal for use in mucogingival surgeries, grafting, and regenerative procedures.

Another breakthrough is the application of chitosan-based dressings and self-assembling peptide hydrogels, which provide rapid, effective hemostasis even in patients with bleeding tendencies. These materials are especially valuable in outpatient settings and in patients for whom altering systemic medications (e.g., anticoagulants) is not feasible.[24-25] Their ease of application and biodegradability make them excellent tools in modern periodontal practice.

Nonetheless, the cost and accessibility of some advanced hemostatic agents remain a challenge in many clinical settings, particularly in low-resource regions. Moreover, despite the development of newer materials, there is a need for more randomized controlled clinical trials to evaluate their comparative effectiveness, long-term safety, and influence on periodontal wound healing.

Individual patient assessment remains paramount. Factors such as systemic health, bleeding disorders, medications, and the type of procedure must guide the clinician in selecting the appropriate hemostatic strategy. Multimodal approaches—combining mechanical, chemical, and biological methods—may offer superior results in complex cases.[26]

In conclusion, the field of periodontal surgery is witnessing a transition from conventional to evidence-based, biologically active hemostatic approaches. Embracing these advances will not only enhance clinical outcomes but also improve patient comfort, reduce complications, and support faster recovery. Future research should focus on the development of cost-effective, easy-to-use, and multi-functional hemostatic agents tailored to the diverse needs of periodontal surgery.

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6. Conflict of Interest

None.

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